The chemical equilibration volume: measuring the degree of thermalization [1]

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We address the issue of the degree of equilibrium achieved in a high energy heavy-ion collision. It has been proposed that kinetic equilibrium will be achieved early and will be followed by chemical equilibration. As no strange hadrons constitute the ‘in state’, the production of such hadrons serves as an indicator of the degree of chemical equilibration, or the the size of the volume over which chemical equilibration has been achieved.

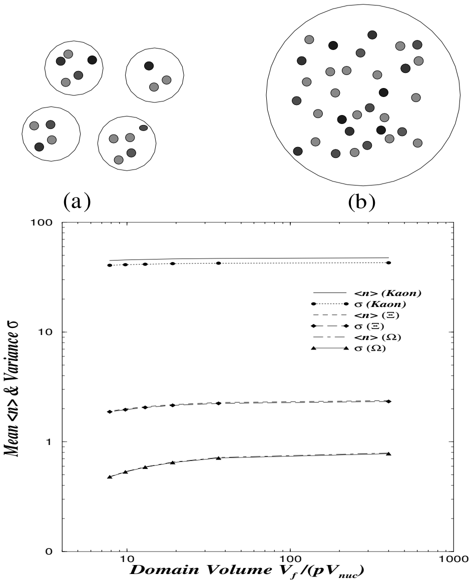

FIG. 1: Fig. 1. The upper panel shows two alternative scenarios, where thermalization is achieved: a) over a small domain, b) over the full system. The lower panel plots the mean and variance for Kaons, Ξ’s and Ω’s for a $T = 170$MeV, and a total freeze-out volume $V_f = 400V_{nucleon}$. The number of domains varies from 1 to 51.

In this work chemical equilibrium is assumed to have been established over a volume V of the order of the strangeness correlation length. It is assumed to be much smaller than the freeze-out volume V_f. Strict strangeness conservation is implemented over this small volume via the canonical ensemble. Efficient recursion relation techniques have been developed which greatly simplify numerical calculations with exact conservation conditions. The estimation of the domain size may be performed by noting the behavior of the probability distributions of various strange particles as a function of number of domains p. These probability distributions are, in principle, measurable in heavy-ion collisions. The main influence of such a situation is shown to be on the distributions of multiply strange hadrons such as the Ω particles (Fig. (2)).

The behavior of the mean numbers of Kaons, Ξ’s and Ω’s in Fig. (1) and the numbers seen in experiments indicate that domain sizes of the order of a nucleon volume are eliminated. The question reduces to resolving the domain size between $V = 20V_{nucleon}$ to domain size of the order of the freeze-out volume $V = V_f$. The occurrence of a large chemical equilibration volume allows for the presence of a quark gluon plasma earlier in the collision. A definite result for V will involve an accurate determination of the probability distributions of the Kaons, Ξ and especially the Ω particles,

Alternatively, one may determine the yields with much greater accuracy than presently imposed in heavy ion collisions (see *e.g.*, Fig. (1)). We also pointed out that measurements of two particle correlations, such as the variance, may lead to incorrect conclusions regarding the amount of canonical suppression faced by different strangeness carriers.

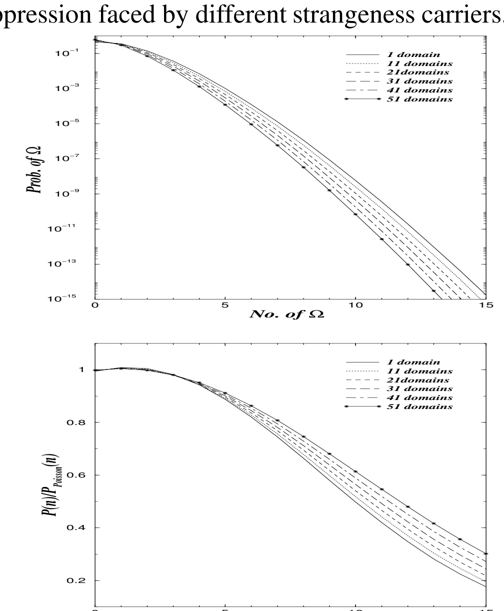

FIG. 2: The upper panel shows the distributions of Ω particles. The volume is divided into 1-51 domains. The distributions shift towards the left. The mean for each distribution is calculated and is used to compute Poisson distribution. The ratio of the calculated distributions to the corresponding Poisson distributions is plotted in the lower panel.

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